

**LIFE HISTORY AND LABORATORY REARING OF
GELASTOCORIS OCULATUS OCULATUS (FABRICIUS) (HEMIPTERA:
GELASTOCORIDAE) WITH DESCRIPTIONS OF IMMATURE STAGES¹**

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Abstract. — The life history of *Gelastocoris oculatus oculatus* (Fabricius) was investigated in southern Illinois during February–November 1991 and 1992, and the immature stages were described. The bug was also reared from egg to adult under controlled laboratory conditions. This apparently univoltine species occurred along the shorelines of ponds and slow-moving fresh water streams. Adults overwintered under rocks above the shoreline and became active in March. Eggs were found in June and July, embedded between the fibers of algal mats of *Cladophora* sp. and *Rhizoclonium* sp. above the shoreline. Seasonal occurrences of adults and immatures are discussed. Adults were last observed in late October. This species was reared under a 16L:8D photoperiod and $29 \pm 1.5^\circ$ C. The incubation period averaged 9.21 days. Durations of the five nymphal stadia averaged 9.55, 7.49, 10.18, 17.36, and 19.83 days, respectively.

Key Words: Toad bug, Gelastocoridae, southern Illinois, life history, laboratory rearing, immature stages, descriptions

The predaceous family Gelastocoridae is represented in the continental United States by two genera, *Gelastocoris* and *Nerthra*. Members of both genera are short, broad, and warty in appearance which, along with their hopping habit, has earned them the common name of toad bugs. *Gelastocoris* species are semiaquatic insects found in open mud or sand beaches along fresh water. Some *Nerthra* species also have been found in littoral areas similar to *Gelastocoris*, but others have been found far from water (Menke 1979). Reported collecting sites include under stones and other objects on banks of streams and ponds, often burrowed

in the soil (Menke 1979); in decomposing banana trunks, rotting logs, and leaf litter on the forest floor (Todd 1955); in cow dung (Lauck and Wheatcroft 1958); and in water (La Rivers 1953).

Gelastocoris contains two species north of Mexico (Todd 1955). The first of these, *G. oculatus* (Fabricius), contains two subspecies; the nominate subspecies occurs widely throughout the continental United States and into Canada and Mexico, while *G. o. variegatus* (Guérin-Méneville) has a more southernly distribution, ranging from Texas to Central America. The second species, *G. rotundatus* Champion, has a primarily southwestern distribution, occurring in California, Arizona, and Texas, and southward to Central America (Todd 1955).

Although *G. o. oculatus* is widely distributed in the continental United States (Pol-

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hemus and Polhemus 1988), little detailed information has been published on its life history. Adults and possibly nymphs overwinter; Hungerford (1919) stated that adults overwinter in sand, Froeschner (1962) that adults overwinter under drift and debris along stream and pond banks, and Blatchley (1926) that adults and older nymphs overwinter in cavities in mud and muck along stream and lake margins. Hungerford (1922) stated that eggs are laid in sand, and Brooks and Kelton (1967) in sand, mud, and under stones. Deonier et al. (1976) conducted experiments on substrate and moisture preferences of adults. Hungerford (1922) found that developmental time under uncontrolled conditions varied from 60 to 100 days. Uhler (1884) reported that *G. o. oculatus* sometimes had a "second brood" (i.e., was bivoltine?) throughout the Atlantic States. Mackey (1972) determined that it was univoltine in eastern Tennessee. He based his conclusion on seasonal occurrences of the following: females with eggs, yolk in developing oocytes, sperm in spermathecae, and adults in five nymphal instars in the field. Although Mackey's field data were based on observations made every two weeks, he weakened his results by combining the data into monthly intervals. Hungerford (1922) provided excellent illustrations of the immature stages but included only brief descriptions of these stages.

This study presents information on the life history of *G. o. oculatus* in southern Illinois and on laboratory rearing, and includes descriptions of the immature stages.

MATERIALS AND METHODS

Life history

Information on field life history was gathered at several sites in 1991 and 1992. In 1991, sites included Winter's Pond at the La Rue-Pine Hills Research Natural Area, Union Co.; Clay Lick Creek, 1.5 mi. SSW of Makanda, Jackson Co.; and Spring Creek,

0.5 mi. NNW of the Hwy 146 bridge over Lake Kinkcaid, Jackson Co. In 1992, sites included Clay Lick Creek; Crab Orchard Creek, Williamson Co.; Campus Lake, Southern Illinois University at Carbondale, Jackson Co.; and Cooper Creek, Union Co.

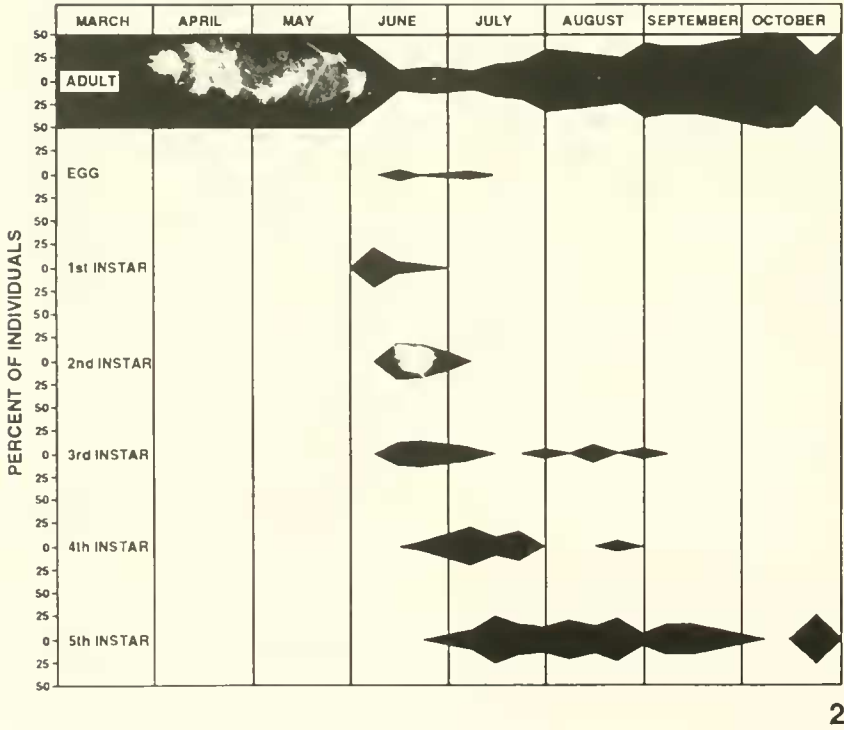
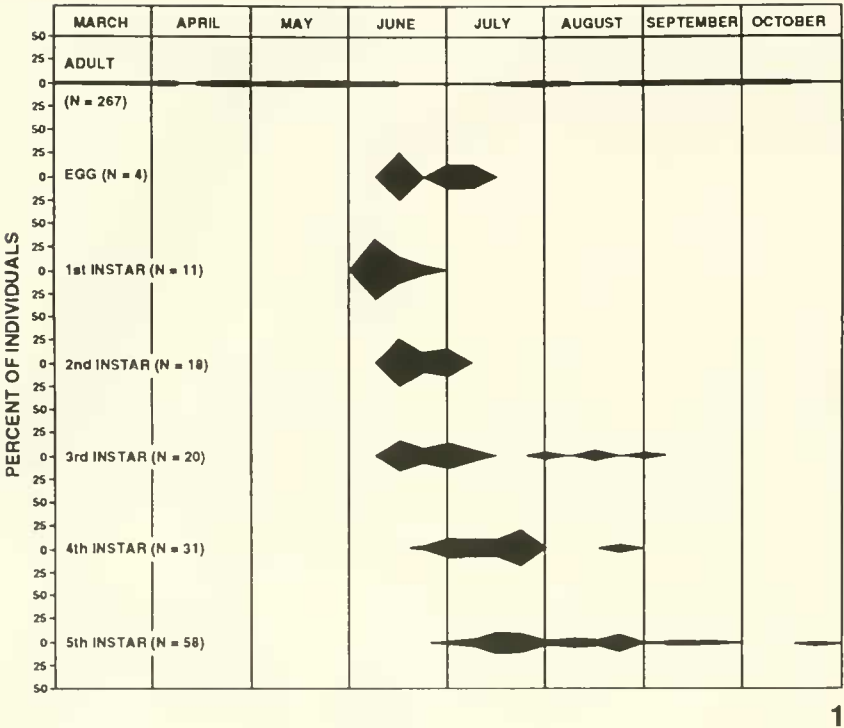
In 1991, samples were collected monthly from 24 March to 20 October. In 1992, they were collected, or counts of nymphs and adults were recorded, weekly from 8 March to 28 October. Specimens were collected by hand-picking (eggs, third through fifth instars, and adults) or with an aspirator (first and second instars) and preserved in 80% ethanol. Data from the two years were combined to gain a better understanding of the annual life cycle.

Laboratory rearing

Sixty-two adults were captured at Crab Orchard Creek on 26–27 May 1992 and brought to the laboratory. They were sexed and pairs placed in covered petri dishes (1 M, 1 F/dish). Each dish (about 9 cm diam, 2 cm deep) was covered on the bottom with a disc of filter paper moistened with distilled water, and contained five to eight pieces of aquarium gravel. Eggs were removed daily and placed on moist filter paper in dishes similar to those used for adults but without gravel. Nymphs were reared individually in dishes similar to those used for eggs. Distilled water was added as needed to all dishes to keep the filter paper moist.

Adults and fifth instars were fed two live *Tenebrio molitor* L. larvae daily; first through fourth instars were fed two, three, five, and eight live *Drosophila melanogaster* Meigen wingless adults daily, respectively. All carcasses were removed the following day. Exuviae were removed daily and the numbers and instars of these exuviae recorded.

All eggs, nymphs, and adults were kept in incubators maintained at $29 \pm 1.5^\circ\text{C}$ and 16L:8D photoperiod (3 fluorescent "day-light" lamps, about 260 ft-c).



Descriptions of immature stages

The description of each stage is based on ten individuals. Second through fifth instars were selected from field collected individuals, eggs and first instars from field collected and laboratory reared individuals. All had been preserved in 80% ethanol. Those that had swelled in the alcohol were not used in the descriptions. Drawings were made with a camera lucida, measurements with an ocular micrometer. Dimensions are expressed in mm as $\bar{x} \pm \text{SE}$.

RESULTS AND DISCUSSION

Life history

Adults emerged from overwintering sites in early March, and were found continuously until late October (Figs. 1, 2). Only one overwintering site was discovered: two adults were found beneath rocks at Crab Orchard Creek on 28 November. By April, riding and copulating pairs were observed; in both behaviors, the male was on top. Copulatory pairs were observed up to the end of July, but riding behavior was noted as late as mid-September. Females were observed to capture flies while being ridden.

Eggs were found from early-mid-June to mid-July but, based on the first appearance of first instars (see below), the oviposition period probably began in mid- to late May (Figs. 1, 2). They were laid between the fibers of moist algal mats of about 90% *Cladophora* sp. and 10% *Rhizoclonium* sp. above the shoreline. These mats had been left behind after spring flooding as the water level receded.

This species has five instars, as reported by Hungerford (1922) and confirmed by Mackey (1972). First instars were found during June (Figs. 1, 2), and usually occurred at least 1 m from the shoreline. When

disturbed, they often crouched instead of jumped, making them difficult to distinguish from sand grains and dirt particles.

Second instars were found from early-mid-June to early July, third instars from early-mid-June to early September, fourth instars from mid-the third week of June to late August, and fifth instars from late June to late October (Figs. 1, 2).

This species is apparently univoltine in southern Illinois, the results closely corresponding to those of Mackey (1972) for eastern Tennessee. Our conclusion is based primarily on the times of occurrence of the eggs, nymphal instars, and gravid females. During 1992, females were examined for mature eggs; their eggs were classified as mature using the criteria of Mackey (1972) (i.e., larger than 1.00×1.25 mm). All females collected before 18 July were gravid and probably were overwintered individuals (Table 1). All collected after 9 August were not gravid and probably were newly emerged females (see time of occurrence of fifth instars [Figs. 1, 2]). Samples collected between late July and early August contained both gravid and nongravid females. These results agree with those of Mackey (1972).

The bugs fed on adult flies and immature spiders including *Gonomyia* sp. (1 specimen) (Tipulidae), *Corynoneura* sp. (1) (Chironomidae), *Leptocera* sp. (1) (Sphaeroceridae), *Lispe* sp. (2) (Muscidae), and two lycosids, *Schizocosa* sp. and an unidentified specimen. One nymph was preyed upon by *Pardosa milvina* (Hentz) (Lycosidae).

Laboratory rearing

Copulation and riding behaviors were frequently observed in the laboratory as they were in the field. Eggs were laid on or between fibers of the filter paper, or glued to

Figs. 1, 2. 1, Percent in each sample of total individuals of same stage of *G. o. oculatus* collected during 1992 season. 2, Percent of individuals of each stage of *G. o. oculatus* per sample during 1992 season.

Table 1. Occurrence of eggs in *G. o. oculatus* from southern Illinois during 1992.

Date	Total No. Females Examined	Gravid Females		
		No.	Frequency (%)	Eggs Female (\bar{x})
11 April	1	1	100	10.0
16 May	3	3	100	10.6
14 June	2	2	100	9.0
20 June	2	2	100	11.0
27 June	3	3	100	18.0
5 July	2	2	100	14.5
11 July	2	2	100	19.0
18 July	6	6	100	9.8
25 July	5	1	20	11.0
1 Aug	5	4	80	6.7
9 Aug	4	0	0	—
21 Aug	2	0	0	—
31 Aug	3	0	0	—
6 Sept	4	0	0	—
13 Sept	5	0	0	—
20 Sept	2	0	0	—
27 Sept	4	0	0	—

the pieces of gravel. Each egg was white at oviposition, but turned yellowish with brown markings during maturation.

The incubation period averaged 9.21 days

(Table 2). Eyespots were visible within five days, legs within one day of hatching. The first through fifth stadia averaged 9.55, 7.49, 10.18, 17.36, and 19.83 days, respectively (Table 2). The total developmental period averaged 73.62 days.

Stadia for all instars except the fourth are shorter than those reported by Hungerford (1922), but survival rates were approximately the same (Table 2). His bugs were reared under uncontrolled conditions. Thus, it is possible that Hungerford's longer stadia resulted from lower temperatures. Preliminary trials confirmed Hungerford's observation (1922) that nymphs are highly cannibalistic.

Mortality was highest in the fifth instar and resulted from incomplete ecdysis and because several bugs did not feed on *T. molitor* larvae.

Descriptions of immature stages

Egg (Fig. 3A): Length, 1.34 ± 0.04 ; width, 0.80 ± 0.05 . Eggs laid singly or in small groups of two or three on or in sub-

Table 2. Duration (in days) of each immature stage of *G. o. oculatus* under laboratory conditions in the present study^a and that of Hungerford (1922)^b.

Stage	Present Study				Hungerford			
	No. Completing Stadium	Range	$\bar{x} \pm SE$	Cumulative Mean Age	No. Completing Stadium	Range	\bar{x}	Cumulative Mean Age
Egg ^c	155	8–10	9.21 ± 0.53	9.21	—	12–15	12.0	12.0
Nymph								
1st instar	114	6–16	9.55 ± 2.09	18.76	49	4–44	15.0	27.0
2nd instar	110	4–18	7.49 ± 1.54	26.25	33	8–33	16.0	43.0
3rd instar	106	6–36	10.18 ± 3.56	36.43	22	8–59	15.0	58.0
4th instar	90	8–45	17.36 ± 6.23	53.79	18	7–34	15.5	73.5
5th instar	30	9–39	19.83 ± 6.31	73.62	13	12–29	22.0	95.5

^a Controlled conditions.

^b Uncontrolled conditions.

^c 194 eggs were laid.

Fig. 3. Immature stages of *G. o. oculatus*. A, Egg. B, first instar. C, Second instar. D, Third instar. E, Fourth instar. F, Fifth instar.

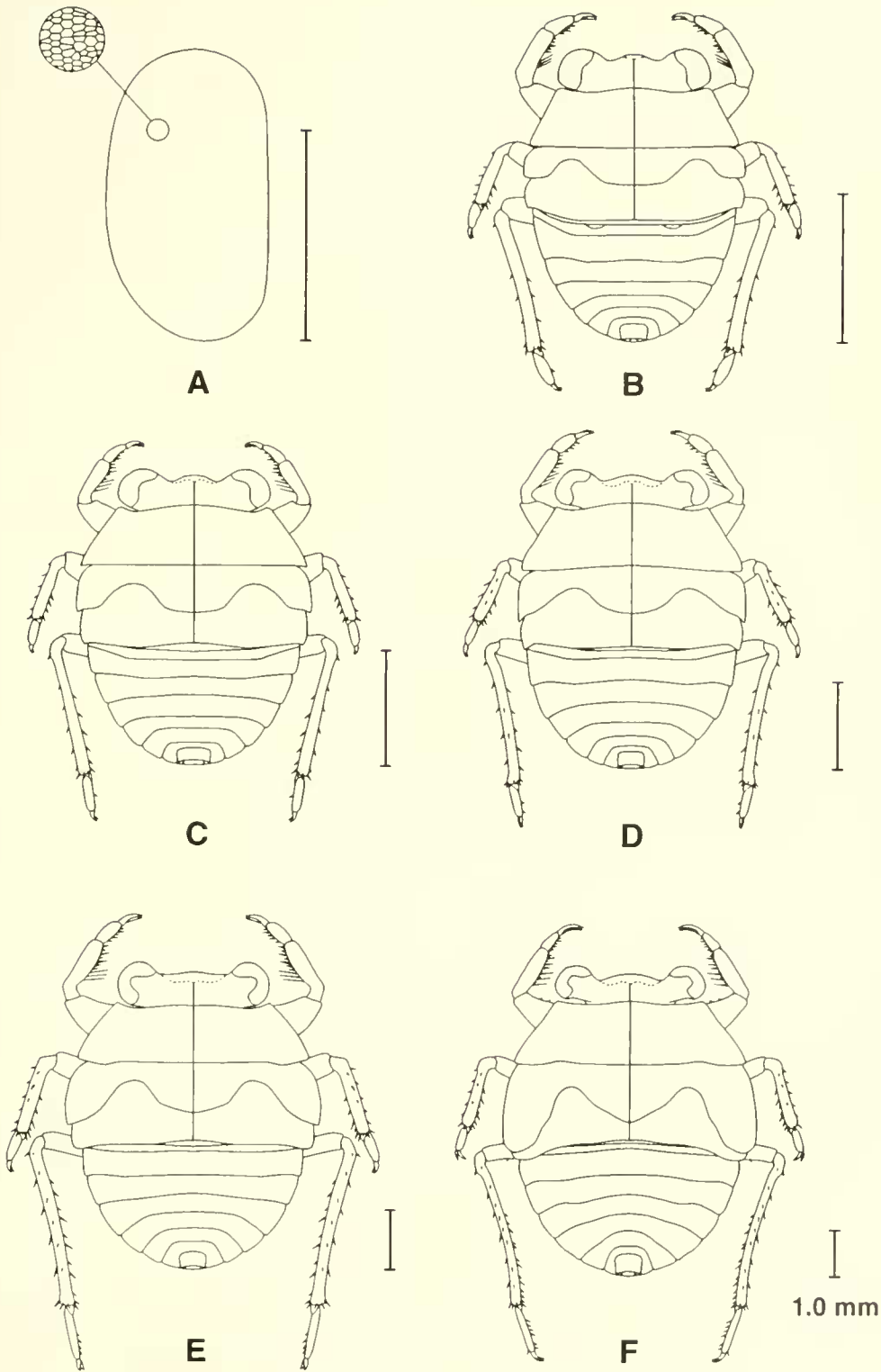


Table 3. Measurements (mm)^a of *G. o. oculatus* instars^b.

	Nymph				
	1st Instar	2nd Instar	3rd Instar	4th Instar	5th Instar
Body length ^c	1.82 ± 0.05	2.50 ± 0.11	3.46 ± 0.27	4.55 ± 0.22	6.37 ± 0.26
Body width	1.45 ± 0.03	1.98 ± 0.08	2.72 ± 0.15	3.73 ± 0.12	5.30 ± 0.22
Width at eyes	1.13 ± 0.01	1.49 ± 0.02	1.89 ± 0.07	2.39 ± 0.05	3.08 ± 0.07
Synthlipsis	0.61 ± 0.02	0.77 ± 0.06	0.98 ± 0.06	1.25 ± 0.06	1.68 ± 0.06
Abdomen width	1.34 ± 0.02	1.76 ± 0.10	2.44 ± 0.11	3.31 ± 0.10	4.43 ± 0.18
Head length ^c	0.20 ± 0.02	0.25 ± 0.05	0.39 ± 0.16	0.43 ± 0.16	0.62 ± 0.17
Pronotal length ^c	0.36 ± 0.01	0.50 ± 0.04	0.70 ± 0.05	0.94 ± 0.04	1.36 ± 0.06
Mesonotal length ^c	0.25 ± 0.01	0.40 ± 0.07	0.54 ± 0.06	0.73 ± 0.05	1.19 ± 0.11
Metanotal length ^c	0.23 ± 0.02	0.28 ± 0.03	0.35 ± 0.03	0.42 ± 0.05	0.45 ± 0.03
Leg lengths					
Profemur	0.51 ± 0.01	0.73 ± 0.11	0.94 ± 0.05	1.29 ± 0.05	1.75 ± 0.05
Protibia	0.42 ± 0.03	0.57 ± 0.03	0.75 ± 0.05	1.00 ± 0.03	1.33 ± 0.07
Protarsus	0.18 ± 0.02	0.23 ± 0.00	0.31 ± 0.03	0.40 ± 0.03	0.53 ± 0.04
Mesofemur	0.55 ± 0.02	0.77 ± 0.09	1.04 ± 0.05	1.46 ± 0.09	2.01 ± 0.09
Mesotibia	0.46 ± 0.02	0.65 ± 0.02	0.88 ± 0.06	1.17 ± 0.05	1.63 ± 0.04
Mesotarsus	0.18 ± 0.02	0.23 ± 0.02	0.31 ± 0.01	0.43 ± 0.04	0.57 ± 0.03
Metafemur	0.66 ± 0.02	1.00 ± 0.03	1.41 ± 0.07	1.99 ± 0.06	2.78 ± 0.09
Metatibia	0.84 ± 0.03	1.28 ± 0.05	1.79 ± 0.07	2.37 ± 0.09	3.34 ± 0.13
Metatarsus	0.26 ± 0.01	0.36 ± 0.02	0.53 ± 0.03	0.74 ± 0.02	1.10 ± 0.05

^a $\bar{x} \pm \text{SE}$.^b Based on 10 individuals of each instar.^c Measured along midline.

strate, or glued to gravel; each egg elongate-oval, whitish at oviposition but turning yellowish with brown markings during maturation; chorion with irregular hexagonal pattern.

Nymphal instars: The first nymphal instar is described in detail, but only major changes are described for subsequent instars. Length is measured from the anterior edge of the vertex to the tip of the abdomen, width across the mesonotum. Additional measurements are given in Table 3. Terminology of the head follows that of Parsons (1959).

First instar (Fig. 3B): Length, 1.82 ± 0.05 ; width, 1.45 ± 0.03 . Body elongate oval, greatest width at mesothorax, dorsoventrally flattened; head with dorsal surface moderately setose, thorax and abdomen with dorsal surface sparsely setose; dorsal surface yellowish with light to dark brown maculations, ventral surface yellowish.

Head, from dorsal view, broad, narrower

medially than laterally, markedly expanded laterally at eyes; anterior margin trisinate, narrowly concave medially (= dashed line); abruptly declivent from lateral view, face vertical; epicranial suture extending from posterior margin of head anteromedially and then bifurcating, each epicranial arm extending obliquely to just before anteroventral margin of eye; face divided by epicranial arms into frontoclypeus ventrally and vertex dorsally. Ocellar spots present submedially in epicranial arms. Frontoclypeus laterally curving posteriorly so that it is visible in lateral view. Maxillary plate adjacent and posterior to frontoclypeus, extending from near base of antennae to base of beak. Gula and postocciput well developed, forming ventral side of head. Eyes red, brown or black, protuberant and somewhat pedunculate, inner margin broadly emarginate; dorsal synthlipsis near anterior margin of eye about $2.0\times$ width of eye. Antennae three-segmented; segments one and two

quadrate, segment three globose, segments one and two subequal, each about $\frac{2}{3}$ length of three. Beak four-segmented, tapering distally; segments one-three yellowish, segment four brown, extending to procoxae. Labrum narrow, extending between tips of maxillary plates.

Thoracic nota with whitish area laterally, particularly well developed on pronotum, contrasting with yellow and brown areas of remainder of pronotum. Sterna and pleura yellowish. Nota convex medially, explanate laterally; widths of meso- and metanota, and pronotum at posterior margin, subequal; yellowish line present medially, continuous with epicranial suture of head and reaching or almost reaching posterior margin of metanotum. Pronotum transverse, trapezoidal; width shorter anteriorly than posteriorly; anterior margin weakly arcuate medially; lateral margin almost straight; posterior margin straight medially; tumescent area each side of disc. Mesonotum about $0.7 \times$ length of pronotum along midline; anterior margin nearly straight; posterior margin straight medially, markedly arcuate each side of disc, straight near lateral margin; lateral margin arcuate. Metanotum slightly narrower than mesonotum along midline, broader each side of disc; posterior margin weakly bisinuate; lateral margin arcuate, subequal in length to that of mesonotum; tumescent area each side of disc, delimited anteriorly by arcuate margin of mesonotum.

Prothoracic legs raptorial; coxa white, conical; trochanter hemispherical with two rows of spines ventrally; femur flattened laterally, broad proximally, tapering distally, two irregular rows of spines ventrally in proximal half, ventral surface of segment flattened; tibia rounded on dorsal and lateral surfaces, medial and ventral surfaces flattened, two ventral rows of spines, medial surface with short row of long setae proximally, sparsely setose on outer surface; tarsus one-segmented, slightly setose, rounded on outer surface, flattened on inner surface

with two rows of spines, two tarsal claws well developed. Mesocoxa whitish, conical; trochanter subreniform, single row of spines, in distal one half; femur with ventral row of two to three spines proximally, sometimes only single spine present, single medial spine usually present subapically on ventral surface; tibia with two longitudinal rows of spines on ventral surface and one row on anterolateral surface, semicircle of spines on same surfaces at apex, single spine present basally on anterolateral surface, tibia setose on outer surface; tarsus two-segmented, slightly setose, segment one shortest, two tarsal claws present, about $0.6 \times$ the length of prothoracic claws. Metacoxa and trochanter similar in shape and color to those of mesothoracic leg, but trochanter lacking spines; femur longest of femora, lacking ventral longitudinal rows of spines, single medial spine present subapically on ventral surface; tibia with two rows of spines ventrally in distal $\frac{1}{2}$ to $\frac{2}{3}$, another row of spines on anterolateral surface in distal $\frac{1}{2}$, single spine present proximally on anterolateral surface, semicircle of spines subapically; tibia setose on outer surface; tarsus two-segmented, slightly setose, segment one shortest, segment two with one or two spines ventrally on each side, two tarsal claws present, about $0.5 \times$ the length of the prothoracic claws. Meso- and metatibiae and tarsi with faint annulations on some specimens.

Abdomen convex medially, explanate laterally, terga and sterna 2-4, 2-5, or 2-6 laterally each with alternating brown and white areas. Abdominal spiracle one adjacent to metacoxa and distant from lateral margin; spiracles two and three more medially located; spiracle four about equal distance from lateral margin as spiracle one; spiracles four and five laterad of two and three; spiracle five much reduced; spiracle six apparently present, difficult to detect, in line with four and five. Abdominal tergum one may be hidden beneath metanotum; two hemispherical pale yellow maculations on anterior of abdominal tergum two.

Second instar (Fig. 3C): Length, 2.50 ± 0.11 ; width, 1.98 ± 0.08 . Body with dorsal surface moderately setose, maculations on thorax becoming more variable and extensive.

Epicranial arms present, but not as clearly evident. Eye with inner margin more emarginate, dorsal synthlipsis near anterior margin of eye about $1.5 \times$ width of eye.

Thoracic nota often lacking lateral whitish areas. Pronotal width at posterior margin subequal to metanotal width, mesonotum slightly wider, medial yellow line on nota not as evident; medial anterior area of pronotum somewhat tumescent, tumescent area also present each side of disc; mesonotum about $0.8 \times$ length of pronotum along midline; metanotum about $0.7 \times$ length of mesonotum along midline; posterolateral corners of meso- and metanota more acute.

Mesofemur with one or two ventral rows of spines proximally, sometimes only one or two spines in each row, single medial spine present subapically on ventral surface. Metafemur occasionally with one or two weak spines proximally; single medial spine present subapically; tibia with two rows of spines ventrally and another row anterolaterally, all rows in distal $\frac{2}{3}$. Meso- and metatibiae and tarsi with annulations darker and often more visible than in first instar.

Abdominal terga and sterna 2-4, 2-5, or 2-6 with alternating brown and white areas not evident in some specimens. Abdominal tergum one with pale yellow maculations not evident in some specimens.

Third instar (Fig. 3D): Length, 3.46 ± 0.27 ; width, 2.72 ± 0.15 . Body with dorsal surface more setose.

Eyes more pedunculate, inner margin more emarginate, dorsal synthlipsis near anterior margin of eye about $2.0 \times$ the length of eye. Antennal segments one and two subequal, each about $0.5 \times$ length of three, segment three elliptical.

Thoracic nota similar to second instar, sterna and pleura occasionally with brown

maculations. Pronotum with anteromedial and lateral areas of each disc tumescent. Mesonotum about $0.8 \times$ length of pronotum along midline, slightly extending posteromedially. Metanotum about $0.6 \times$ length of mesonotum along midline, posterior margin more arcuate medially. Meso- and metanotum with posterolateral corners more acute; mesonota with lateral margin about $1.4 \times$ that of metanotum.

Prothoracic trochanter with two rows of spines ventrally and pair of spines laterad of each row; femur with two irregular rows of spines ventrally in proximal $\frac{2}{3}$; outer surface of tibia setose. Mesofemur with two ventral rows of spines in proximal $\frac{2}{3}$, occasionally with proximal spine interior to anteroventral and posteroventral rows of spines; tibia with fourth longitudinal row of spines present on dorsal surface, tarsal claws about $0.8 \times$ length of protarsal claws. Metafemur with sparse, posteroventral row of two-five short spines, present in proximal $\frac{1}{2}$ to $\frac{2}{3}$, anteroventral spine present distally in proximal $\frac{2}{3}$, single medial spine present subapically on ventral surface; tibia occasionally with fourth longitudinal row of spines on dorsal surface, circle of spines present subapically; tarsal segment two with one row of spines on anteroventral side and one or two spines on posteroventral side. Pro-, meso-, and metafemora and tibiae and meso- and metatarsi with annulations darker and more often visible than in second instar.

Fourth instar (Fig. 3E): Length, 4.55 ± 0.22 ; width, 3.73 ± 0.12 . Dorsal surface of body more setose.

Dorsal synthlipsis near anterior margin of eye about $2.2 \times$ length of eye. Ocellar spots now appearing as ocelli; outer margin more clearly defined.

Pronotum with posterior margin straight medially, concave to sinuate in lateral $\frac{1}{3}$; mesonotum with posterior margin extending posteromedially, lateral margin about $2.5 \times$ that of metanotum; medial and submedial areas tumescent; metanotum with

medial area tumescent; areas each side of notal disc more tumescent than earlier instars, tumescent areas of meso- and metanota contiguous; mesonotum about $0.8 \times$ length of pronotum along midline; metanotum about $0.6 \times$ length of mesonotum along midline; posterolateral areas of meso- and metanota broader because of developing wing pads.

Procoxa with three short spines on posterior margin apically, trochanter with four irregular rows of spines ventrally, femur with two irregular rows of spines in proximal $\frac{2}{3}$, 2 or 3 more spines laterad of each row proximally; tibia with posteroventral row of spines now irregular. Mesotrochanter whitish, two rows of spines in distal $\frac{1}{2}$; femur occasionally with two anteroventral rows of spines, making total of three ventral rows in proximal $\frac{2}{3}$, occasionally also with one to four proximal spines interior and exterior to anteroventral and posteroventral rows, single medial spine present apically on ventral surface; tibia with anteroventral row of spines becoming more spinose, fourth longitudinal row of spines on dorsal surface more spinose; tarsal segment two may have one to four spines anteroventrally. Metafemur with posteroventral row of spines in proximal $\frac{2}{3}$, anteroventral in middle $\frac{1}{2}$, single medial spine present apically, tibia with longitudinal row of spines dorsally, two rows of spines ventrally, one row of spines anterolaterally; tarsal segment two may have second row of spines on anteroventral side, posteroventral spines may be developed into a complete row. Pro-, meso- and metafemora may have faint annulations.

Fifth instar (Fig. 3F): Length, 6.37 ± 0.26 , width 5.30 ± 0.22 . Body more oval, dorsal surface more setose.

Ocellus now dome-shaped. Eyes more pedunculate, synthlipsis about $2.3 \times$ width of eye.

Mesonotum with posterior margin extending more posteromedially, visible portion of lateral margin about $9.0 \times$ that of

metanotum; tumescent areas more pronounced, mesonotum about $0.9 \times$ length of pronotum along midline, wing pads extending almost to tip of metanotal wing pads; metanotum $0.4 \times$ length of mesonotum along midline, wing pads reaching third abdominal segment.

Procoxa with four to seven short spines on posterior margin apically; trochanter with three irregular posteroventral rows of spines, and two irregular anteroventral rows of spines; femur with two irregular rows of spines in proximal $\frac{3}{4}$, each row one to three spines wide at base; tibia with two posteroventral rows of spines and one anteroventral row of spines. Mesocoxa occasionally with one or two medial spines present apically; tarsal claws $0.5 \times$ length of prothoracic claws. Metatibia with single spine present basally on anterolateral surface, another present basally on dorsolateral surface; tarsal segment two may have one spine posteroventrally and one to four spines anteroventrally, with one to two spines in dorsomedial surface in apical $\frac{1}{3}$; tarsal segment two with one row of anteroventral spines, one row of lateral spines, and one posteroventral row of spines, tarsal claws $0.7 \times$ length of prothoracic claws.

Diagnosis

The five nymphal instars, in addition to size, can be readily separated by the relative lengths of the meso- and metanota; the number of spines, particularly on the legs; and the presence or absence, and degree of development, of wing pads. There is a progressive decrease in the relative length of the metanotum to the mesonotum through all instars because of the increasing posterior extension of the posteromedial area of the mesonotum, and a progressive increase in the number of spines. In addition, the fourth and fifth instars possess definite wing pads; the mesonotal wing pads of the fourth instar are about $\frac{1}{2}$ the length of those of the

fifth and almost cover the metanotal wing pads in the fifth.

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